PATENT SPECIFICATION

706,342

Inventor:—WALTER GEORGE MARSKELL.

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COMPLETE SPECIFICATION.

Improvements in or relating to Pressure Tight Joints between Tubular Elements.

We, BABCOCK & WILCOX LIMITED, a British Company, of Babcock House, Farringdon Street, London, E.C.4, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to pressure tight joints between tubular elements required to operate while heated and formed of steels having different coefficients of thermal expansion.

In order to improve the efficiency of steam turbine plants, progressively higher pressures and higher temperatures of superheat have been adopted. Such high temperatures and pressures have introduced metallurgical problems, in the provision of reliable superheaters, which might be alleviated by the use of austenitic steels. Such steels, however, are relatively expensive and frequently an advantage in cost would be gained by using an austenitic steel for a high temperature section of superheater and a ferritic steel for an associated low temperature section of superheat. Such arrangement may call for a substantial number of joints between austenitic and ferritic steel tubes. In any case the introduction of a superheater or section of superheater of austenitic steel into a system composed in general of ferritic steel would entail at least two pipe or tube joints between parts respectively of austenitic and ferritic steel. For this reason a difficulty arises, since in order to form reliable joints, normal methods of jointing are inapplicable on account of thermal expansion differences and, in the case of welded joints, local variations in composition of the metal at the weld. The provision of joints of improved reliability for the purpose in question is, therefore, a matter of considerable importance.

The present invention includes the method of making a pressure tight joint between tubular elements required to operate in a heated condition and formed of steel having different coefficients of thermal expansion, which comprises circumferentially ridging or grooving a surface portion of an element, positioning a terminal part of the element formed of the steel having the larger coefficient of thermal expansion within the element formed of the steel having the lower coefficient of thermal expansion, with the said surface portion in contiguity with a surface of the other element and effecting a flow of metal causing conformity in shape of and intimate contact between at least circumferentially continuous parts of the two contiguous surfaces.

The invention also includes a pressure tight joint between tubular elements formed respectively of austenitic and ferritic steel, wherein a length of the austenitic steel element extends within a length of the ferritic steel element with at least one circumferentially continuous part of its outer surface in intimate contact with the opposing surface of the ferritic steel element, whilst locking means adapted to inhibit relative longitudinal movement of the elements include at least one projection on one element extending within a complementary recess in the other element.

The invention furthermore includes a pressure tight joint between tubular elements formed respectively of austenitic and

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ferritic steel, wherein a length of the austenitic steel element extends within a length of the ferritic steel element, the inner surface of the ferritic element is formed with a series of circumferentially continuous grooves and the outer surface of the austenitic element is formed with a corresponding series of projections which respectively extend at least part way into the grooves, whilst at least over circumferentially continuous parts flanking the grooves and projections the two surfaces are in intimate contact.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a longitudinal section through two tubular steel elements jointed in accordance with the present invention;

Figure 2 is a sectional view of part only of the jointed elements shown in Figure 1, but drawn to a much larger scale than in that Figure;

Figure 3 is a longitudinal section through one of the tubular elements shown in Figure 1, before it is jointed to the second tubular element;

Figure 4 is an end view of the tubular elements shown in Figure 1, looking from the right-hand side of that Figure;

Figure 5 is a longitudinal section through the second of the tubular elements shown in Figure 1, before it is jointed to the first tubular element;

Figure 6 is a longitudinal section through the two tubular elements immediately prior to their being jointed together; and

Figure 7 is a sectional side elevation through the superheater of a vapour generating and superheating plant to which the invention has been applied.

In Figures 1 to 6 of the drawings, the first tubular element, 1, is made of a ferritic steel and the second tubular element, 2, is made of an austenitic steel.

The tubular element 1 consists of a main part 3 (see Figure 3) of uniform outside diameter and an end part 4 of lesser diameter joined to the main part by a neck 5 the diameter of which gradually increases towards the main part 3. The end part 4 is cut away circumferentially as indicated at 6 to provide one side of a welding groove to facilitate welding of the element 1 when desired to an adjacent tubular member indicated by dotted lines at 7 in Figure 1 and also made of a ferritic steel.

The tubular element 1 is formed internally with a number of shallow circumferential grooves 8 of rectangular cross-section and spaced evenly along the main part 3; in the embodiment shown the longitudinal spacing between adjacent grooves is equal to the width of the grooves and the depth of each groove is equal to one quarter of its width, these relative dimensions having been found to be suitable in a joint in which the internal bore of the end part 4 was $1\frac{1}{8}$ inches, the grooves 8 being $\frac{1}{8}$ inch wide and $\frac{1}{32}$ inch deep. However, a short part of the internal surface of the main part, adjacent the end 9 of the element, is left free from such circumferential grooves, but is formed with four longitudinally extending grooves, 10, equally spaced about the inner circumference of the element, and extending from the end 9 of the element as far as the nearest of the circumferential grooves 8; these grooves 10 are of the same depth as the grooves 8.

The tubular element 2 (see Figure 5) is originally, for substantially its whole length, of an external diameter such as to fit within the intergroove portions of the main part 3 of the tubular element 1. It is also, for substantially its whole length, of an internal diameter equal to the internal diameter of the end part 4 of the tubular element 1. Near one end 11 of this element 2, however, its internal diameter gradually increases towards the end of the element, as shown at 12, while at its opposite end, the element is cut away circumferentially as indicated at 13 to provide one side of a welding groove to facilitate its welding to an adjacent tubular member, indicated by dotted lines at 14 in Figure 1, also made of an austenitic steel.

Figure 6 illustrates one method of forming a fluid tight joint between the two elements. First the end 11 of the tubular element 2 is inserted through the end 9 of the tubular element 1 into that element as far as is shown in Figure 6, and a mild steel support ring 15 is fitted onto the outside of part 3 of the tubular element 1 and then the tubular element 2 is expanded within the tubular element 1 in suitable manner. Advantageously the expansion is effected by means of a retractive tube expander and Figure 6 shows a retractive tube expander 16 inserted into the inner tubular element 1 in readiness for the expanding operation.

The tube expander 16 includes three tapered rollers such as 17 arranged to lie in slots e.g. 18 equally spaced about the circumference of a body part 19, and to be forced out radially against the adjacent parts of the inner tubular element to be expanded by axial adjustment of a tapered mandrel 20 extending axially of the body part 19 and between the three rollers. The mandrel is screw-threaded over part (not shown) of its length, and this screw-threaded part engages a correspondingly screw-threaded thrust member 21 which is rotatably mounted in the body part 19. Such a tube expander is disclosed in Applicants' Patent No. 686,656.

The actual jointing operation is initiated by first causing axial movement of the mandrel 20 to bring the rollers into contact

with and to swell the tubular element to be expanded, by rotation of the mandrel whilst the thrust member 21 is held against rotation, and then permitting rotation of the thrust member 21 and the body part 19 of the tube expander, whereupon the tubular elements 1 and 2 are expanded locally radially to bring the outer surface of element 1, into contact with the inner surface of the support ring 15 and (due to the inclination of the slots and rollers in the body part 19) the body part 19 is moved outwardly along the inner element, progressively expanding radially that part of the tubular element 2 which is within the outer element 1. When this first expansion has been completed, the expander is given a second pass through the same part of the tubular element 2, and during this pass, a plastic deformation of the metal of the inner element takes place so that metal of the element flows into the grooves 8 and 10 formed in the outer element 1, as is illustrated most clearly in Figure 2, in connection with a groove 8. When the expanding operation is completed, the expander 16 is withdrawn through the end part 4 of the outer element 1 and the support ring 15 is driven off the main part 3 of the outer element 1.

With the joint shown in Figure 1, the beads of metal of the inner element which have been formed in the longitudinal grooves 10 of the outer element effectively prevent relative rotation of the inner element relative to the outer element, the engagement of the beads of metal of the inner element which have been formed in the circumferential grooves 8 of the outer element effectively prevent withdrawal of the inner element from the outer element, and the plurality of circumferentially continuous areas of intimate contact between the inner and the outer elements inhibit leakage of pressure fluid from the inside to the outside of a tube of which the two jointed elements eventually form part. Moreover, when in operation the complete tube is raised to an elevated temperature, since the coefficient of expansion of the inner element 2 is greater than that of the outer element 1, the pressure between the inner and the outer members in the circumferential areas of contact already referred to becomes even greater, and the joint is found to be capable of withstanding without seepage of the pressure fluid much higher pressures when at high temperatures than when cold.

Figure 7 illustrates such a superheater forming part of a tubulous vapour generating and superheating unit, in which a plurality of superheating tubes 30 are connected at their ends to inlet and outlet headers 31 and 32 respectively. The superheater comprises a low temperature primary section 33 formed by tubular members 34 made of a ferritic steel and connected to the inlet header 31 and a high temperature secondary section 35 formed by tubular members 36 made of an austenitic steel and connected to the outlet header 32. Each tube 30 comprises a tubular member 34 and a tubular member 36 having their adjacent ends connected together by a joint 38 similar to that described above in connection with Figures 1 to 6. In operation, hot gases flow upwardly first over the secondary section 35 formed of the austenitic steel and then over the primary section 33 formed of the ferritic steel.

The invention may be applied to the jointing of two relatively long tubular elements formed of steels having different coefficients of thermal expansion, without the use of short intermediate jointing elements as has been described with reference to Figures 1 to 6. In such a case, it is not feasible to expand the inner element as has been described above with reference to Figures 1 to 6, and it is necessary to reduce the diameter of the outer element, for example by forging or by drawing the part containing the joint through a suitable die, so as to create at least one circumferentially continuous zone of intimate contact between the inner and the outer elements. When the austenitic element is of too large a diameter to fit within the ferritic element, preferably the end of the ferritic element is enlarged to such a size as to take the end part of the austenitic element. It has been found desirable, when a joint is to be made by reducing the diameter of the outer element, to form the circumferential grooves and longitudinal grooves in the outer surface of the inner member.

What we claim is:—

1. The method of making a pressure tight joint between tubular elements required to operate in a heated condition and formed of steel having different coefficients of thermal expansion, which comprises circumferentially ridging or grooving a surface portion of an element, positioning a terminal part of the element formed of the steel having the larger coefficient of thermal expansion within the element formed of the steel having the lower coefficient of thermal expansion, with the said surface portion in contiguity with a surface of the other element and effecting a flow of metal causing conformity in shape of and intimate contact between at least circumferentially continuous parts of the two contiguous surfaces.

2. The method of making a pressure tight joint as claimed in Claim 1, which comprises forming the inner surface of the outer element with a number of longitudinally spaced circumferential grooves and effecting the flow of metal by increasing the internal diameter of the inner of the two elements

without causing any substantial increase in the external diameter of the outer of the two elements.

3. The method of jointing two tubular members formed respectively of austenitic and ferritic steel, which comprises first making a pressure tight joint between two relatively short tubular elements, respectively formed of austenitic and ferritic steel, as set out in Claim 1 or Claim 2 and subsequently welding the austenitic member to the austenitic tubular element and the ferritic member to the ferritic tubular element.

4. A pressure tight joint between tubular elements formed respectively of austenitic and ferritic steel, wherein a length of the austenitic steel element extends within a length of the ferritic steel element with at least one circumferentially continuous part of its outer surface in intimate contact with the opposing surface of the ferritic steel element, whilst locking means adapted to inhibit relative longitudinal movement of the elements include at least one projection on one element extending within a complementary recess in the other element.

5. A pressure tight joint as claimed in Claim 4, wherein at least one annular projection on the one element extends with a complementary annular recess in the other element.

6. A joint as claimed in Claim 4, or Claim 5, wherein there is a series of longitudinally spaced circumferential projections each substantially of rectangular cross-section.

7. A joint as claimed in Claim 4, Claim 5 or Claim 6, wherein an element is formed with at least one projection in engagement with a corresponding recess in the other element and adapted to inhibit relative rotation of the two elements.

8. A pressure tight joint between tubular elements formed respectively of austenitic and ferritic steel, wherein a length of the austenitic steel element extends within a length of the ferritic steel element, the inner surface of the ferritic element is formed with a series of circumferentially continuous grooves and the outer surface of the austenitic element is formed with a corresponding series of projections which respectively extend at least part way into the grooves, whilst at least over circumferentially continuous parts flanking the grooves and projections the two surfaces are in intimate contact.

9. A heat exchanger comprising a plurality of tubes each of which includes a tubular member arranged to be subject to relatively high temperatures and formed of an austenitic steel and a tubular member arranged to be subject to lower temperatures and formed of a ferritic steel, wherein each tube includes a pressure tight joint between its tubular members, as claimed in any one of Claims 4 to 7.

10. A pressure tight joint between tubular elements of austenitic and ferritic steel, substantially as described hereinbefore with reference to Figures 1 to 6.

11. The method of making a pressure tight joint between tubular elements of austenitic and ferritic steel, substantially as described hereinbefore with reference to Figures 1 to 6.

12. A superheater in which primary and secondary sections are formed by tubular members respectively of ferritic and austenitic steel, the tubular members being connected together by joints substantially as described hereinbefore with reference to Figure 7.

For the Applicants,
A. C. PRICE,
Chartered Patent Agent.

PROVISIONAL SPECIFICATION.

Improvements in or relating to Pressure Tight Joints between Tubular Elements.

We, Babcock & Wilcox Limited, a British Company, of Babcock House, Farringdon Street, London, E.C.4, do hereby declare this invention to be described in the following statement:—

This invention relates to pressure tight joints between metallic tubular elements required to operate while heated and formed of metals having different coefficients of thermal expansion.

In order to improve the efficiency of steam turbine plants, progressively higher pressures and higher temperatures of superheat have been adopted. Such high temperatures and pressures have introduced metallurgical problems, in the provision of reliable superheaters, which might be alleviated by the use of austenitic steels. Such steels, however, are relatively expensive and frequently an advantage in cost would be gained by using an austenitic steel for a high temperature section of superheater and a ferritic steel for an associated low temperature section of superheater. Such

arrangement may call for a substantial number of joints between austenitic and ferritic steel tubes. In any case the introduction of a superheater or section of superheater of austentic steel into a system composed in general of ferritic steel would entail at least two pipe or tube joints between parts respectively of austenitic and ferritic steel. For this reason a difficulty arises, since in order to form reliable joints, normal methods of jointing are inapplicable on account of thermal expansion differences and, in the case of welded joints, local variations in composition of the metal at the weld. The provision of joints of improved reliability for the purpose in question is, therefore, a matter of considerable importance.

The present invention includes the method of making a pressure tight joint between metallic tubular elements required to operate in a heated condition and formed of materials having different coefficients of thermal expansion, which comprises circumferentially ridging or grooving a surface portion of at least one of the elements, positioning a length of the element of material having the large coefficient of thermal expansion within the other element with the said surface portion of the one or each element in contiguity with a surface of the other element and effecting a flow of metal causing intimate contact between and conformity or substantial conformity in shape of the adjacent surfaces of the elements.

Frequently, it may be necessary or desirable to form at least one of the elements in more than one length including a short jointing length and a second length of material having the same or substantially the same coefficient of thermal expansion as the jointing length and to weld together the jointing length and the second length after the formation of the joint.

The flow of metal may be produced, for example, by acting upon the interior of the inner element by a tube expander, or the outer element may be forged onto the inner element. Alternatively the flow of metal may be effected by reducing the external diameter of the outer element through the action of a die.

Suitably only the inner element is circumferentially grooved on the outer surface. The grooves may be distributed substantially throughout the length of the inner element within the outer element. Advantageously the grooves are formed with square shoulders, and by way of example, each groove has a depth of the order of one sixteenth of an inch and a width of the order of one eighth of an inch. The distance apart of the grooves may be greater than the width thereof.

The invention also includes the method of making a pressure tight joint between tubular elements respectively of austenitic and ferritic steel which comprises inserting a length of austenitic steel tubular element within a length of ferritic steel tubular element and reducing the inner and outer diameters of the outer length and causing the latter to exert a compressive force on the inner length by the action of a die in a drawing operation. The austenitic steel tubular element may be inserted within the ferritic steel tubular element over a substantial distance.

At least one of the elements may be formed in more than one length including a jointing length acted upon by the die and an adjacent length, the jointing length and the adjacent length being welded together after the drawing operation.

The invention also includes a pressure tight joint between tubular elements of austenitic and ferritic steel, wherein a length of the austenitic steel element extends within a length of the ferritic steel element with adjacent surfaces in intimate contact and one of the surfaces is formed with at least one circumferential projection in engagement with a corresponding recess in the other surface.

Suitably there is a series of circumferential projections substantially of rectangular cross-section.

When joints of the nature described above are heated up, expansion of the inner tubular element serves to increase the pressure between the jointing surfaces, thereby helping to maintain the tightness of the joint when operating at high pressures and temperatures.

It may be advantageous to heat a joint above a critical temperature before applying pressure or the full pressure, and the invention further includes the method of operating a high pressure, high temperature tubular vapour generating and superheating unit comprising at least one joint between austenitic and ferritic tubular elements for conducting superheated vapour of which a length of the austenitic element extends and fits within a length of the ferritic element, according to which, during starting of the unit, and before the applicant of any or any but a relatively low vapour pressure to the joint, the joint is heated sufficiently to ensure pressure between co-operating surfaces of the joint adequate to give a tight joint at full vapour pressure.

For the Applicants,
A. C. PRICE,
Chartered Patent Agent.

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from which copies may be obtained.

FIG.1.

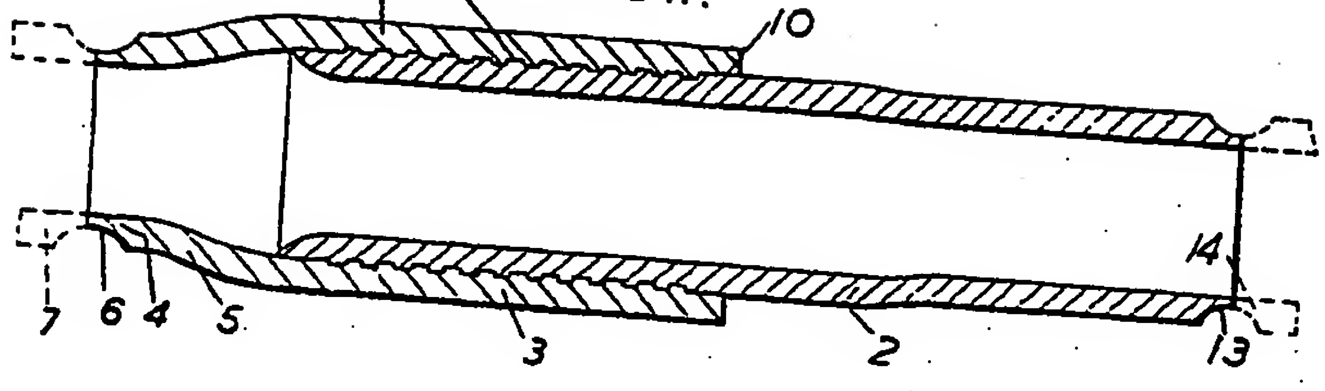

FIG.2.

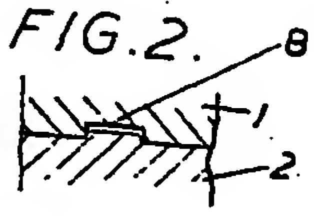

FIG.6.

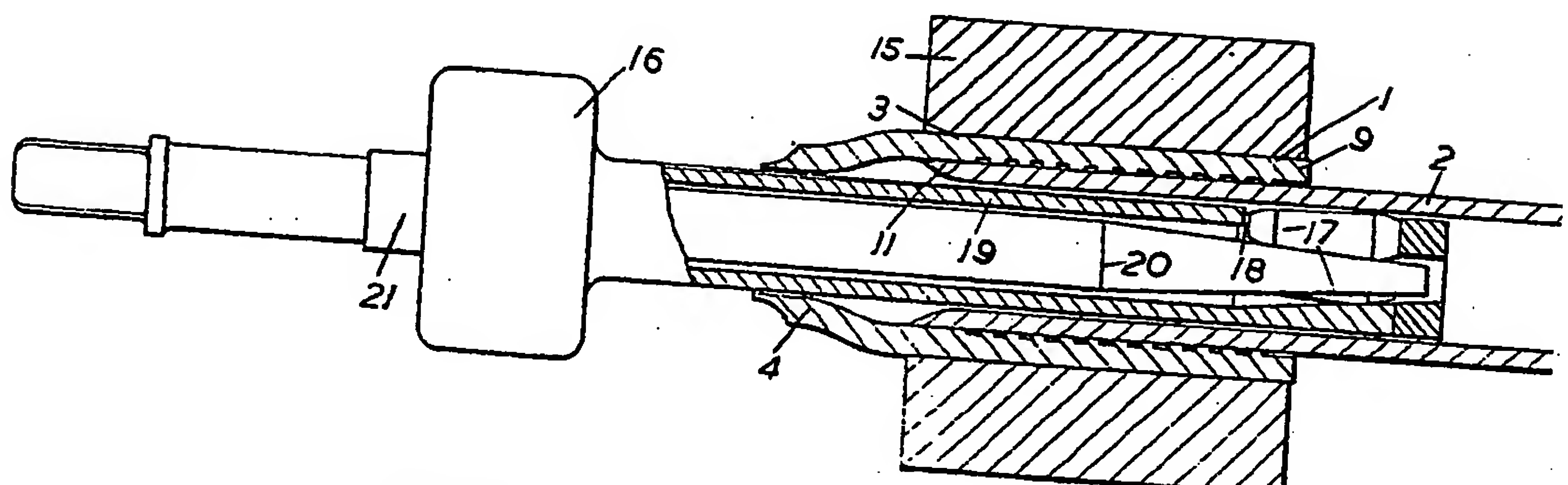

FIG.4.

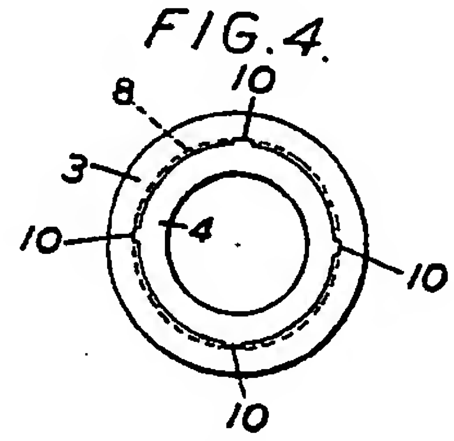

FIG.3.

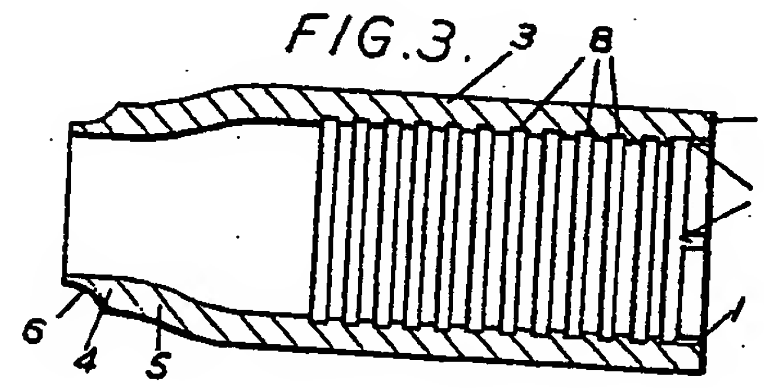

FIG.5.

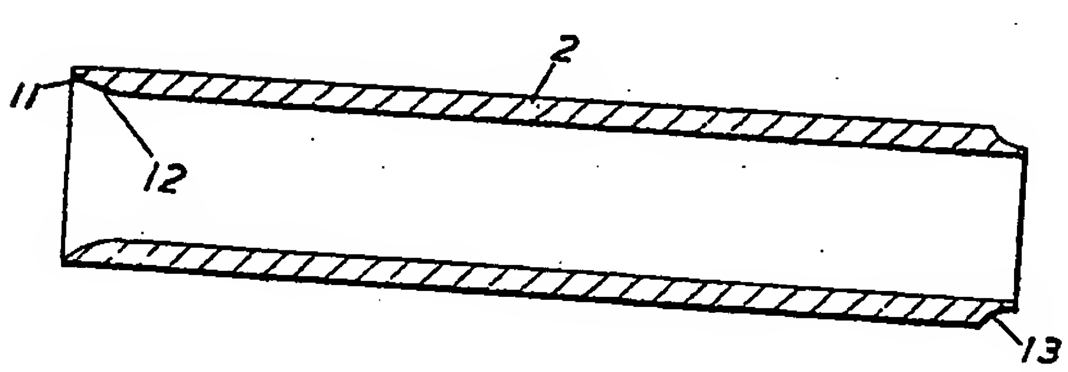

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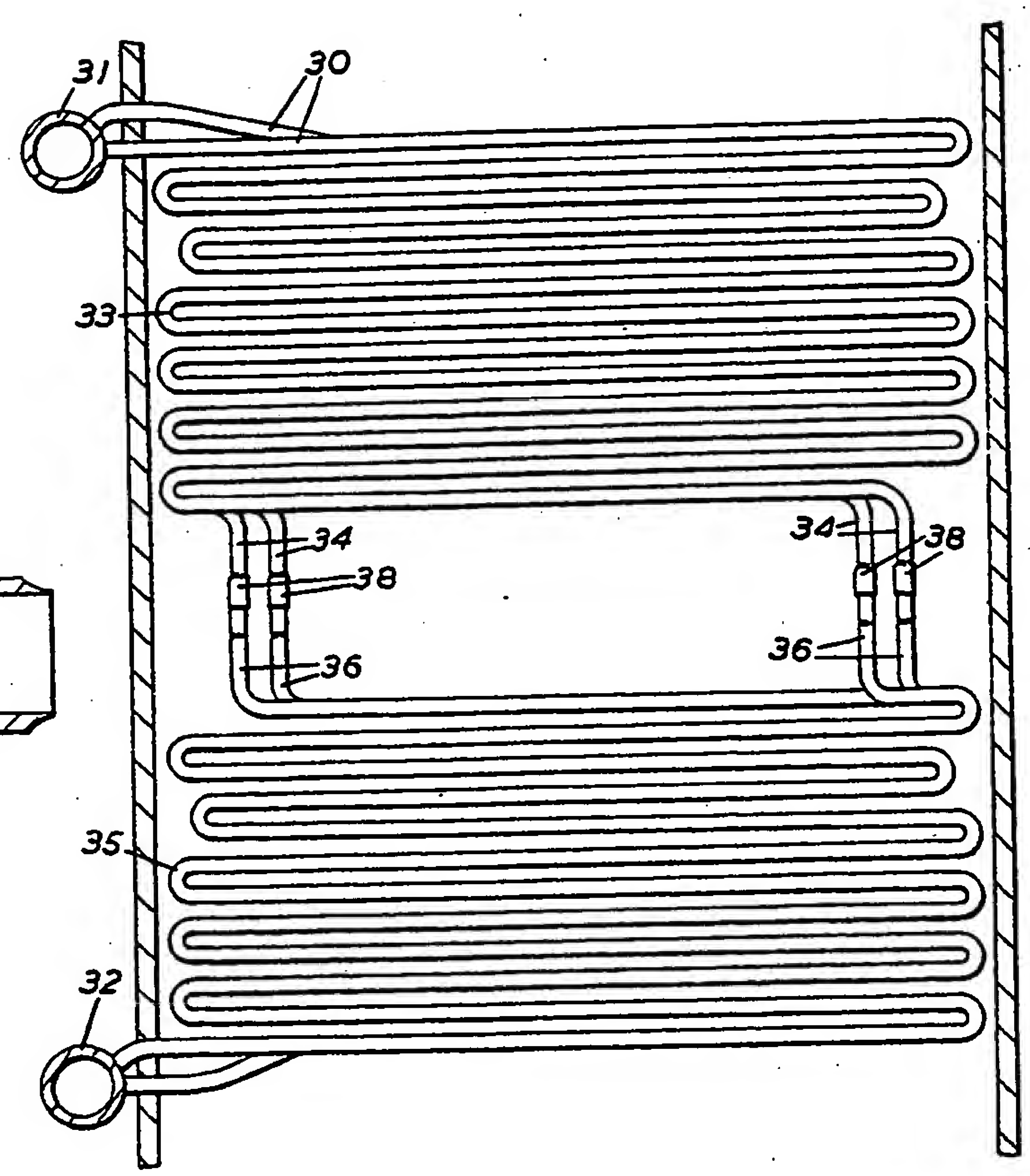
FIG. 7.



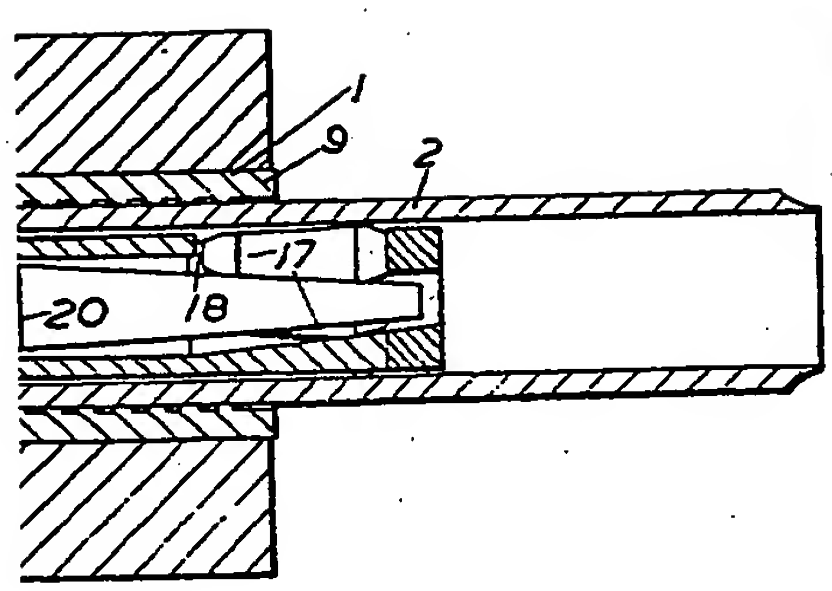


FIG. 3.

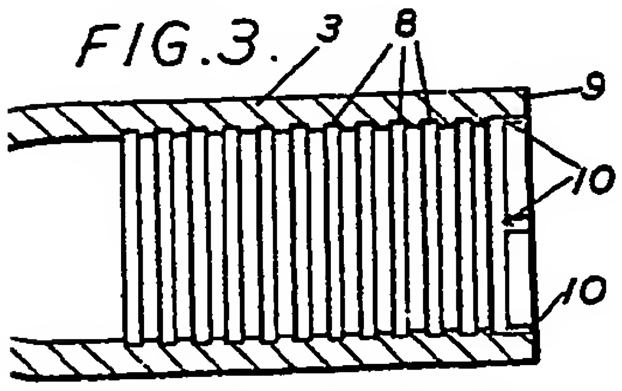


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FIG.1.

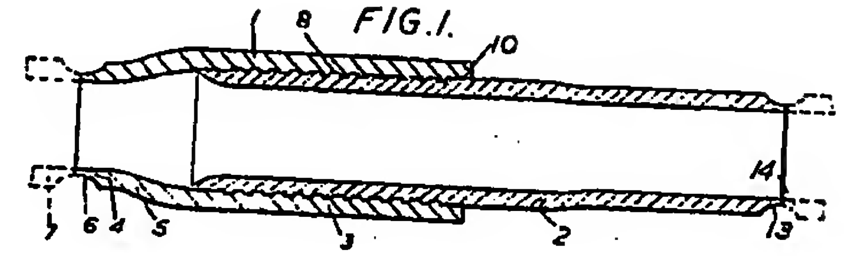

FIG.2.

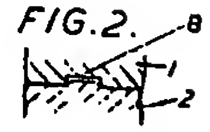

FIG.6.

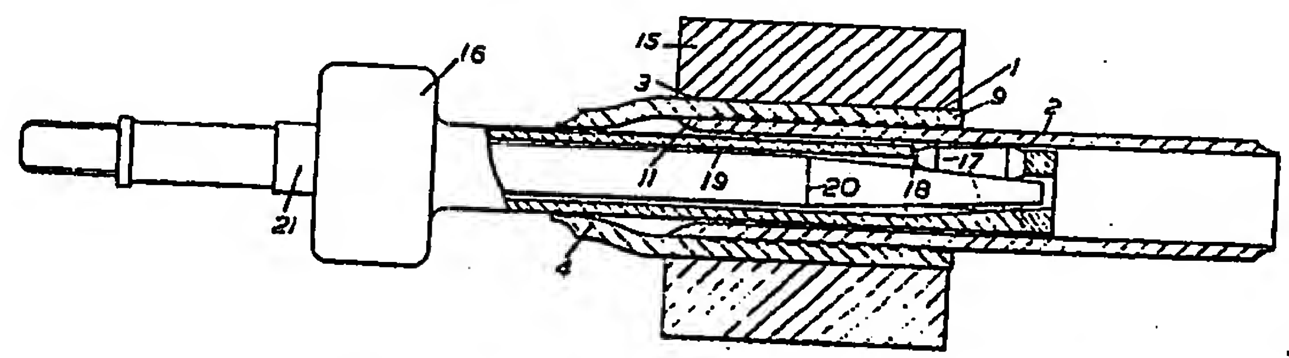

FIG.4.

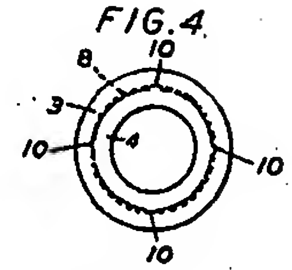

FIG.3.

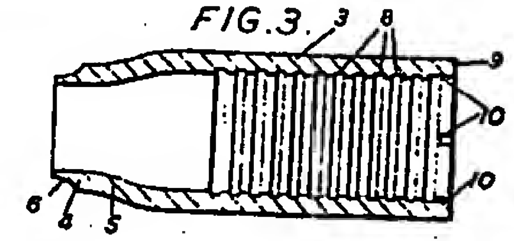

FIG.5.

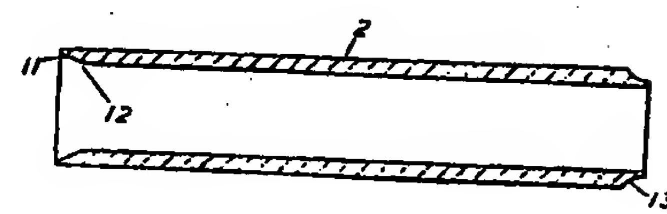

FIG.7.